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Evaluating Reciprocal Coaching as a Differentiated Professional Development Strategy for Experienced Teachers: The Effect of the GK-12 Program on Teachers

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Evaluating Reciprocal Coaching as a Differentiated Professional Development Strategy for Experienced Teachers: The Effect of the GK-12 Program on Teachers

by

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Dedication

To my balcony person, best friend and love – Scott.

To the joy of my life – Tom.

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Abstract

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Professional development is key to improved student and school success, however research in this field is relatively new and teacher learning is often lackluster. Additionally, alternative strategies are needed to address the unique professional development needs of experienced teachers. One possible strategy is classroom-embedded reciprocal coaching, such as that used in the National Science Foundation's GK-12 program, between experienced classroom teachers and graduate student scientists. Teachers were surveyed to determine if their participation in GK-12 provided a positive professional development experience. It was found that teachers benefited from this type of professional development with a perceived increase in their science content knowledge and an overall high level of satisfaction with the program. Interviews revealed common themes, such as the teacher's viewpoint of whether this was professional development, the teachers' areas of learning, the reciprocal nature of the coaching relationship, and the prospect of sustainability.

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Chapter 1: Introduction

The need for professional development for experienced teachers

The National Commission on Teaching and America's Future (1996) set a goal that 80% of our teachers should be "expert" teachers. But how can we bridge the gap between novice teachers and expert teachers? How can we keep teachers on the path of continuous professional growth? Perhaps professional development should use different strategies and have different goals dependent on the stages of the teacher career path. Research has shown differences between how novice and expert teachers learn and how they process the learning experience (Loucks-Horsley et al., 2010), therefore their professional development opportunities should reflect this important difference.

In How People Learn (2000), Bransford et al. identify several key principles distinguishing novices from experts in any domain of knowledge and these can be applied to teachers as well. First, experts not only have more content knowledge, they also have their knowledge organized around "big ideas". Because of this, experienced teachers need professional development focused on new ideas and to be content-specific (Chval et al., 2008). Secondly, experts have a greater ability to be metacognitive, monitoring their own knowledge and being reflective of their teaching practice. As a result, in any professional development experience, the expert teacher is better able to participate in reflective practice than the novice teacher. Third, experts' knowledge tends to be highly contextualized. When surveyed, experienced teachers expressed the need for professional development that was on-going and job-embedded (Chval et al., 2008). So,

the question then is posed – what would good professional development look like for the experienced, expert teacher?

In this study I investigate the effect of classroom-embedded professional development on experienced, expert teachers. I begin by exploring the different stages of a teacher's career to distinguish the differences between a novice, professional and expert teacher. Then, I will discuss the current state of professional development, specifically classroom-embedded professional development. Then, I will introduce the structure of the specific classroom-embedded program used for this study – the GK-12 program – which utilizes a reciprocal coaching dynamic. Then I will detail the current, evidence-based criteria used to evaluate professional development.

From novice to expert - the trajectory of a teacher's career

A teacher's skills, beliefs and actions change over the course of their teaching career. Steffy and Wolfe (1998) describe the stages of the Life Cycle of the Career Teacher:

1) Novice – A novice teacher is one who is acquiring teaching skills through experience in the classroom through pre-service teacher education programs or for some into their induction year. Teachers in this stage may be hesitant and unsure, but their confidence grows as they become sensitive to the classroom setting and their students.

2) Apprentice – An apprentice teacher is one who is refining their knowledge of teaching and learning as they proceed through student teaching and up to their

third year. Teachers in this stage my still have self-doubt and be unsure, but that is usually overshadowed by their energy, idealism and enthusiasm for their work and their students. This is a critical time because many teachers leave the profession during this phase as they become disillusioned.

3) Professional – Professional teachers make up the greater portion on teachers in schools. These teachers have gained self-confidence through their interactions with students and a mutual respect between the teacher and the students is a result. Teachers in this stage value the opportunity for growth.

4) Expert – Expert teachers are described as "with-it" in that they are in tune with the students and the school community. They are committed to new ideas and are connected to other expert teachers. They learn through their role as teachers.

5) Distinguished – Distinguished teachers are few; they are truly gifted and are involved with impacting the larger school structure through policy.

The state of professional development

With the establishment of standards for student learning in science during the late 1980's and early 1990's, it would seem that a plan to achieve these goals would have been developed in tandem. Unfortunately, the action plan seems to be lagging behind. Research suggests that teacher quality is correlated with student achievement (Darling-Hammond, 1999), so it would seem natural to focus on professional development as a means of meeting these standards. However, bad professional development abounds and many studies have catalogued the ways in which teachers have been subjected to

fragmented, incoherent and irrelevant professional development (PD) activities (Wilson & Berne, 1999; Chval et al., 2008). Not surprisingly, teachers report that these experiences did not result in changing their teaching practices or improving their students' learning. The perception of professional development among teachers is something that "has to be done" and often consists of one-shot, disconnected workshops. For teachers, the events in their PD experiences are often unrelated to their every-day classroom responsibilities and do not include the continuing support needed for implementation (Guskey, 2000; Chval et al., 2008).

Despite the lack of good professional development experiences had by many teachers, it does exist. However, what constitutes high-quality professional development is still a relatively new area of research. Specifically, we are just now learning how and what teachers learn through professional development and how teacher learning translates into student outcomes (Borko, 2004; Noyce, 2006; Guskey, 2003). Despite the existence of numerous lists of criteria in publications, only a few studies provide credible, empirical evidence for research-based themes that can be used to develop and evaluate effective professional development (Guskey & Yoon, 2009). Research must now focus on how to correct the mismatch between what teachers want and need and what they have been receiving. This study will specifically examine what good professional development could look like for the expert teacher.

Chapter 2: Background

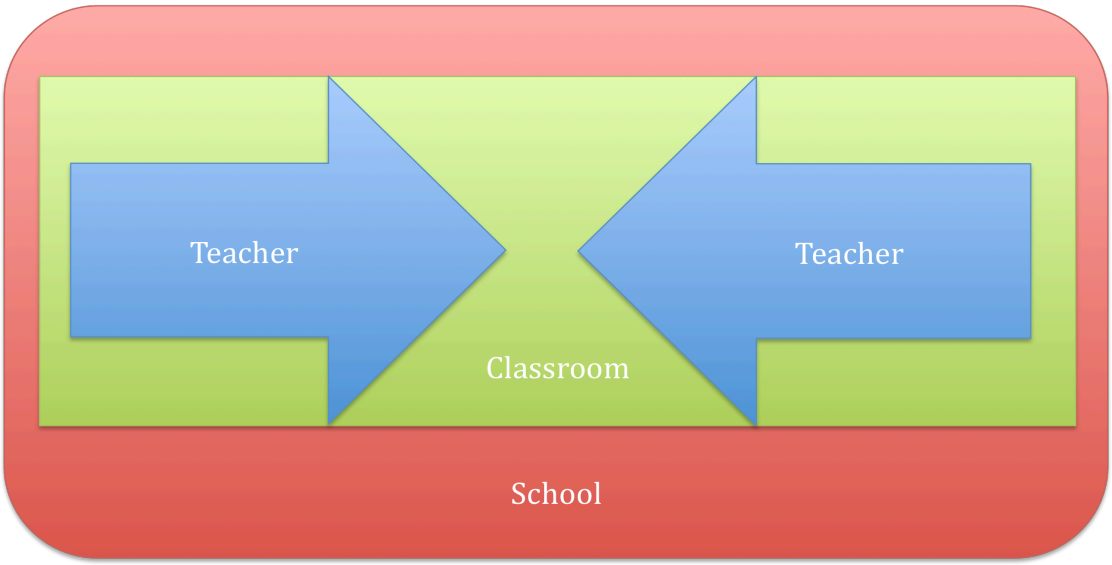
Classroom-embedded professional development

Attending to the differences between novices and experts described above, professional development activities differentiated for experienced, expert teachers should: 1) expose them to new information in the education field and/or their content area, 2) provide opportunities to reflect and collaborate with colleagues, and 3) do so *within their own classrooms* (Rodriguez & McKay, 2010). Professional development that is classroom – or job – embedded is gaining notice both in educational research as well as public policy. The term has been frequently used in recent federal education regulations from the U.S. Department of Education because this type of professional development "connotes a direct connection between a teacher's work in the classroom and the professional development the teacher receives" (National Archives and Records Administration, 2009, p. 58479). Classroom-embedded professional development encompasses any teacher learning that is nested within the day-to-day teaching environment (Darling-Hammond & McLaughlin, 1995). Examples of classroom-embedded PD include: teacher action research, case discussions, lesson study, professional learning communities and coaching (Croft et al., 2010). The last of these – coaching – will be the focus of this research.

Coaching, in contrast to mentoring, focuses on interactions which are about "the technical aspects of instruction, rather than the larger personal and nonacademic features of teaching" (Croft et al., 2010, p.6). Although the scope of activities may differ, basic

activities include: regular discussion about student learning, experimentation with instructional methods, and observation in the classroom (Zwart et al., 2008). Typically, instructional coaches have expert knowledge to share and the interactions are ongoing (Loucks-Horsley et al., 2010). The coaches are usually in a position higher than the teacher.

Figure 1. Traditional reciprocal coaching model with two-teacher dyad



Reciprocal coaching - a subset of the coaching strategy - is defined as activities undertaken in the workplace in which dyads (typically two teachers) support each other where they are more-or-less of the same skill level (see Figure 1). Research suggests that reciprocal coaching produces three positive outcomes: 1) improvements in teachers' pedagogical strategies, 2) improvement in students' academic skills and competencies, and 3) greater teacher satisfaction (Kohler et al., 1997). However, we still are seeking to

understand how the individual professional development practices provide these outcomes.

Although reciprocal coaching dyads are generally two teachers, the GK-12 program (described in more detail below) provided just this type of 'opportunity for learning' through reciprocal coaching. In this program, the teachers were the pedagogical coaches for the graduate student scientists and the scientists were the content coaches for the teachers. This research will utilize the GK-12 program as an example of reciprocal coaching in an attempt to analyze the outcomes and dynamics of reciprocal coaching as a differentiated professional development opportunity for experienced teachers.

The GK-12 program

The National Science Foundation's (NSF) GK-12 Program was created in 1999 and the program was halted in 2011. The program partnered graduate student scientists (called fellows) with K-12 teachers for an academic year. The goals of the program were to:

1. Improve the communication, teaching, collaboration skills of graduate student scientists,
2. Provide professional development to K-12 teachers,
3. Enrich learning of K-12 students, and
4. Foster partnerships between universities and colleges and local school districts (NSF, 1999).

The organization and structure of the program was dependent upon the universities and colleges in which it was housed. In the GK-12 program under study, the graduate student scientists were expected to be in the classroom, interacting with the classroom teacher and students, for a minimum of 12 hours per week. An additional 8 hours per week was spent in planning and other professional development activities such as teaching seminars. The graduate student scientist's role in the classroom evolved over the course of the program, but generally they were serving as "scientists-in-residence" by bringing their areas of research into the classrooms through presentations and class activities. The teachers in this program interacted with the graduate student scientist while they were in the classroom and also met with them for planning. In addition, all participants attended field workshops and scientific lectures throughout the year and the larger group of teachers and scientists met monthly to discuss their experiences.

The GK-12 model was the first major attempt to form a collaborative partnership between university graduate student scientists and K-12 science teachers working together in a K-12 setting in an effort to bridge the gap between science and science education (Thompson et al., 2002). The program followed a common outreach model, "scientist in the classroom", however the longer duration of the interaction between the scientist and the teacher was unique (as compared to scientist guest speakers) and is closely aligned with the reciprocal coaching model. The effects of this type of outreach are presumed to be positive for students, although little research exists to substantiate this claim. In general, the results are affective in that the interactions change student attitudes, however this may just be a measurement of enjoyment rather than true science

learning (Laursen et al., 2007). Even less research exists in how valuable the scientist-in-the-classroom model of outreach is for the teacher. This study will attempt to evaluate the reciprocal coaching professional development strategy as employed by the GK-12 program.

Evaluating professional development

Guskey (2000) defined professional development as an intentional, ongoing, and systemic process. First, PD has to be intentional, meaning that it begins with a clear statement of worthwhile goals and that these goals will be used to assess the program's effectiveness. An example of a worthwhile goal is one that is tied to a school's mission and is focused on learners and learning. Second, PD has to be ongoing by being long-term and job-embedded. The professional development experience should be contextual in nature, increasing the connectedness between the PD and the classroom. Third, PD has to be systemic in that the larger vision is supported at the organizational level as well as at the individual level. This alleviates the "next new thing" view of professional development. Lastly, professional development has to be acknowledged as a process rather than an event. It can take teachers 3 to 5 years to implement changes in their practice and just as long to see the effect on students (Loucks-Horsley et al., 2010). Additionally, the PD program should be continually evaluated and improved as a part of the change process.

There is no singular professional development evaluation tool, but several meta-analyses have been conducted to create lists of the effective research-based

characteristics of professional development. One such list (see Figure 2) was recently used to evaluate the GK-12 program as professional development. Cormas and Barufaldi (2011) found that, while the GK-12 program did include all of the characteristics of professional development, each characteristic was implemented with a great degree of variation between the teacher-scientist dyad and between program sites.

Figure 2. Effective research-based characteristics of professional development

1. Teachers' discipline-specific knowledge is increased.
2. Teachers understand how student learn and what are effective teaching strategies within a specific discipline.
3. Teachers understand how students learn and what are effective teaching strategies.
4. Teacher effectiveness and student achievement outcomes are used to determine whether professional development has worked.
5. Requires resources (time and money).
6. Professional development is on-going.
7. Professional development occurs in day-to-day contexts of teachers.
8. Uses effective teaching strategies.
9. Coherent/aligned with school/district/state goals.
10. Teachers provide input into professional development design; professional development is engaging and relevant.
11. Involves collaboration between teachers and others.
12. Generates further collaboration or projects.
13. Treats teachers as professionals.
14. Promotes teacher self-reflection.
15. Uses inquiry as a teaching style.
16. Increases teacher ability to meet needs of diverse learners.

Research questions

In an extensive literature search, little other research was found relating to the GK-12 program's second goal – to provide professional development for teachers. Much of what has been written focuses on the benefits to the graduate student scientist and that amount is also scarce (Gilmer et al., 2005). Although the primary focus of the program is the graduate student scientist, the work is collaborative in nature and is conducted with a teacher in their classroom. This study seeks to analyze the teacher-scientist relationship in greater detail, with the teacher as the focal point. To that, the research questions are:

1. Do the cooperating teachers view the GK-12 program as effective professional development?
2. And if so, can the GK-12 program be used as a model for reciprocal coaching as a differentiated professional development strategy?

Chapter 3: Methods

The mixed methods implemented in this study were designed to create a telescoping understanding of how the GK-12 program affected the teacher, by first assessing the broader characteristics of the effects through a survey and then a finer examination through one-on-one interviews. In this section, I describe the data collection instruments, the participants, and the data analysis methods.

Survey

The survey was designed to address the first research question: Do the cooperating teachers view the GK-12 program as effective professional development? Most of the survey questions were taken from a national survey that was used to create a final report for NSF in 2010 (Abt Associates, Inc., 2010); as such, I was able to compare local results with national results. A series of additional questions were created by the researcher (see Figures 3 and 4) to mirror Guskey's five levels of evaluation (Guskey, 2000) and were used for a "snapshot" evaluation of the program and to organize discussion of the results.

Sixty-one teachers have participated in the GK-12 program during the six years it was implemented at the two locations used for this study. These teachers have had varied experiences within the program due to changing program themes and foci. For this study, thirty-eight teachers (those with current and correct contact information) were sent an online survey asking them about their GK-12 experience. Twenty-six teachers responded

Figure 3. Guskey's five levels of evaluation and related survey questions

Evaluation Level	Question Asked
1. Participant's Reactions	Enjoyability
	Use of time
	Quality of resources
	Usefulness
2. Participant Learning	Personal benefit gained
	Amount of work
	Application to the classroom
3. Organizational Support and Change	Motivation
	Organization
	Support
4. Participant Use of New Knowledge and Skill	Impact on your content knowledge
	Impact on your teaching skills
5. Student Learning Outcomes	Impact on your students' learning
	Impact on your students' attitudes toward science

Figure 4. Question as it appeared to survey respondents

1. How would you rate your experience in GK-12 as compared to other professional development experiences?

	Below Expectation	Met Expectation	Above Expectation
Enjoyability	○	○	○
Use of time	○	○	○
Quality of resources/materials	○	○	○
Usefulness	○	○	○
Personal benefit gained	○	○	○
Amount of work	○	○	○
Application to the classroom	○	○	○
Motivation	○	○	○
Organization	○	○	○
Support	○	○	○
Impact on your content knowledge	○	○	○
Impact on your teaching skills	○	○	○
Impact on your students' learning	○	○	○
Impact on your students' attitude towards science	○	○	○

to the voluntary and anonymous survey over the two weeks that it was available, resulting in a favorable 65.8% response rate. Response rate was increased through the use of a deadline and three reminder emails (Cook et al, 2000). Of the 26 teachers who entered the online survey, 25 consented for the use of their responses in this research.

The results of the responses of the 25 consented teachers were aggregated and analyzed. At first, I looked for major areas of agreement among the survey participants as seen through either rather large or small percentages of responses to specific questions. Then, I cross-checked responses to questions that were asking about similar topics to see if there was consistency throughout the survey as well as to determine possible explanations for agreement among the participants. For example, I matched the responses of a question concerning goals the teacher had for their participation in the program to responses of a question concerning whether they thought the program had helped them to meet their goals. The results of these comparisons are organized within the "snapshot" evaluation of the program and discussed in the results section.

Interviews

The interview questions were designed to provide more detailed and richer understanding of the second research question: Can the GK-12 program be used as a model for reciprocal coaching as a differentiated professional development strategy? The interview was semi-structured, allowing me to probe more deeply based on the participant's responses. Questions included: "In what types of professional development have you been involved?", "What aspect of the GK-12 program was the most beneficial

for you in terms of a professional development opportunity and why?", and "Are you more or less likely to seek long-term partnerships (such as your work with the fellow) because of your experience with the GK-12 program?" All interviews ended with an invitation for teachers to provide additional comments that they perhaps felt had not been discussed.

The last question of the online survey asked the teacher if they wished to be interviewed about their GK-12 experience. Ten teachers (40% of the consented teachers) agreed to be interviewed, however two of these teachers were not interviewed due to scheduling conflicts. Therefore, seven teachers and one teacher-fellow team (32% of the consented teachers) were interviewed for this paper. Interviews occurred in locations and at times chosen by the teacher— this included classrooms, restaurants, or their personal home and, in total, took place over the span of one month. All of the interviews were digitally video-recorded; additionally, field notes were taken during the interview.

The interviews were transcribed and analyzed for common themes. An iterative, data-driven analytical method was used to identify similarities and differences within the interview responses of the teachers (Corbin & Strauss, 1990; Aronson, 1994). Analysis began with several readings of all of the transcripts. The transcripts were then open-coded noting major ideas the teachers discussed, and the codes were refined through a second careful reading of the interview transcripts. These open codes were then used to develop topic categories that seemed to be shared among teachers' responses. Then, each open code was assigned to a topic category and clustered together for comparison to establish consistency of use. Once consistency was attained, the codes were compared to

determine themes within each topic category. To ensure that the data was being represented accurately and completely, the themes were peer checked and member reviewed. The four themes that emerged through this analysis procedure will be discussed in the results section.

Participant Characteristics

The majority (80%) of the teachers who participated in the survey were secondary science teachers. The teachers tended to be mid- to late- career, experienced teachers with 91% of the teachers having 6 or more years of experience and 25% with more than 21 years of teaching experience. Over one-half (57.1%) of the teachers had a master's degree, usually within some area of education (for example, science education or educational administration).

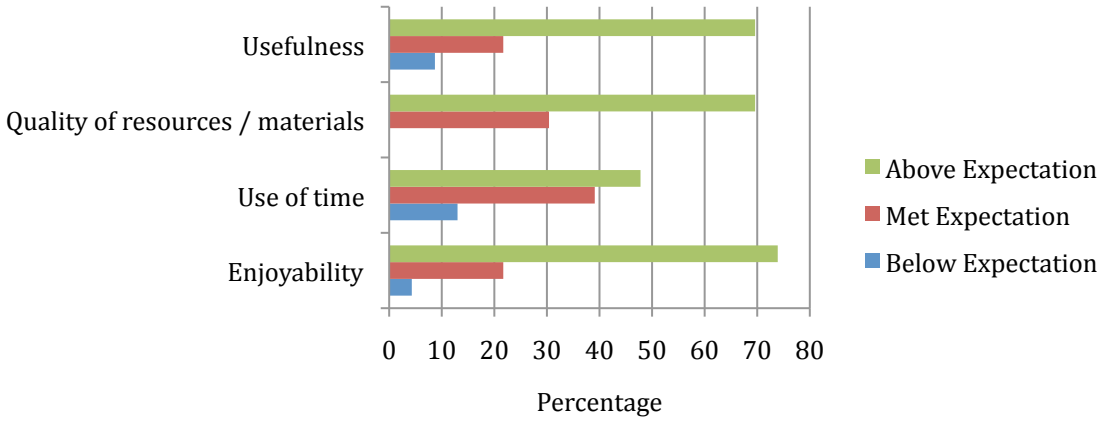
The teachers who participated in the interview had between 5 to 25 years, with an average of 15 years, of teaching experience. They also were mostly middle school science teachers, and 2 had master's degrees. Four of the teachers had participated in GK-12 for several years (one teacher had participated for five years), while the other four teachers had only participated for one year.

Chapter 4: Results

Do the cooperating teachers view the GK-12 program as effective professional development?

To answer this first research question, the results of 25 consented teacher surveys were analyzed. Overall, survey results indicate that these experienced, well-educated teachers perceived that GK-12 provided an effective professional development program. The following will detail the results along five evaluation levels: 1) participant reaction, 2) participant learning, 3) organizational support and change, 4) participant use of new knowledge and skills, and 5) student learning outcomes.

Evaluation Level 1: Participant's Reactions

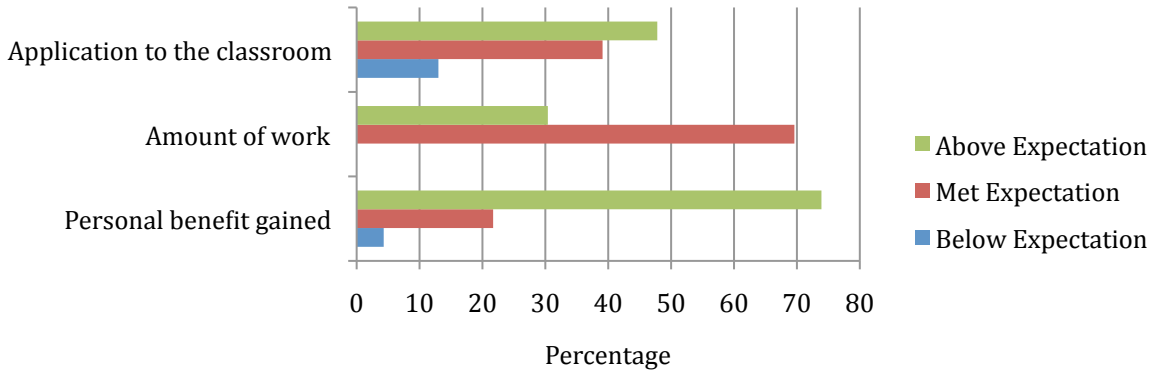


Ideally, these questions would be asked just after a PD session (Guskey, 2000). However, because some of the teacher respondents were in the program over 8 years ago, these results may be more telling of a general positive feeling towards their GK-12

experience rather than a specific recollection. Teachers reported high levels of enjoyment, quality and usefulness. However, use of time was below expectation for 3 out of the 25 teacher respondents and the number of those who responded with 'above expectation' dropped as well; literature suggests that lack of time is often cited as a concern of teachers (Loucks-Horsley et al., 2010). This result is perhaps surprising since it is assumed classroom-embedded professional development would be happening within the normal course of a teacher's daily activities and therefore decrease this common concern. However, because the program did involve 'outside' meetings and workshops, the teachers may have been reporting a misuse of time within those types of activities. A few comments might elucidate what was occurring:

> *Some of the all-participant meetings seem to be irrelevant, done just because they need to be done.*
>
> *I was 1st year implementation, so it was a bit unorganized and learn as you go. That was sometimes frustrating.*
>
> *Time is critical in a 1A school where you teach 5 different subjects, sponsor a club and coach two teams.*

Evaluation Level 2: Participant Learning

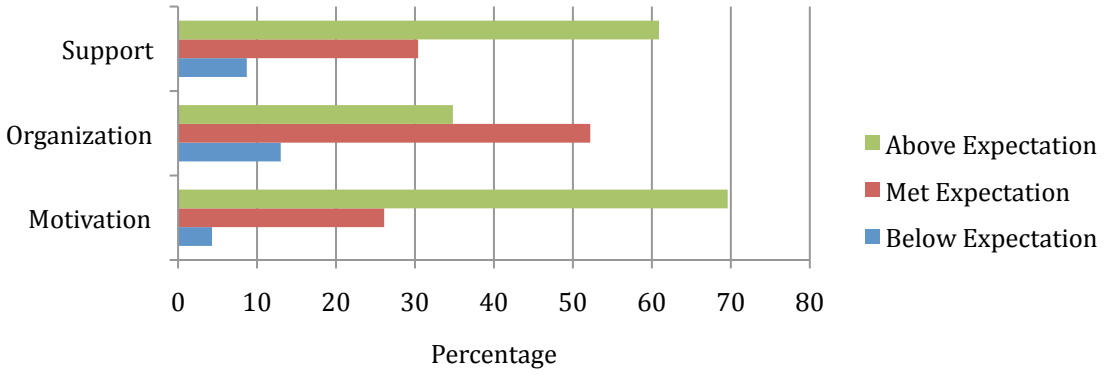


The teachers found value in this professional development experience, with over 70% of the teachers claiming that their personal benefit was above expectation. This result is extremely promising in light that the amount of work for the GK-12 program is considerable. It is estimated that teachers spend approximately 300 hours involved in GK-12 activities such as summer and weekend workshops, monthly meetings, and weekly planning and classroom time with their graduate student scientist. This amount far exceeds the average time spent in professional development where only 13% of teachers spend more than 35 hours annually in PD activities (Chval et al., 2008). Literature suggests that job-embedded professional development (such as the weekly planning and classroom time spent with the graduate student scientist) is more effective because of its strong application to the classroom (Guskey, 2000). Surprisingly, some teachers reported that the application to the classroom was below their expectation. This mismatch could be explained by a few comments made by teachers:

> *The program requirements were in no way aligned with the realities of state standards and required content.*
>
> *The challenge was to incorporate the fellow's science expertise in an elementary classroom and still meet curriculum requirements.*

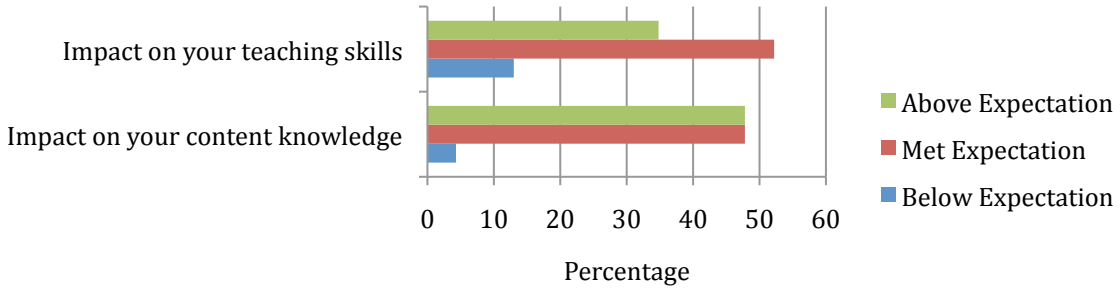
With such emphasis on accountability, standards, and testing, the context in which teachers teach must be addressed. Therefore, if reciprocal coaching is to provide the impact desired, it must be done with these higher level, systemic features in mind.

Evaluation Level 3: Organizational Support and Change



Teachers reported a high level of motivation to enact change in the larger educational context due to the GK-12 program, some of the effects of which were continuing. Because of their involvement in the GK-12 program, teachers reported (in a separate survey question) that they participated in other professional and leadership opportunities such as: pursued continuing education in science content, joined professional organizations, provided workshops on science teaching, wrote articles related to science teaching, and presented at national conferences. Developing teacher leadership – as part of the external domain in which teacher growth occurs – is considered one of the results of a successful coaching partnership (Zwart et al., 2007) and is particularly important for nurturing experienced teachers. The primary organizational support comes from the university, and some teachers reported that their the organization did not meet their expectations. The program is generally run through a program coordinator, and this person can have a great effect on the group's collaborative culture (Loucks-Horsley et al., 2010). This larger organizational aspect should be a consideration in creating productive reciprocal coaching relationships.

Evaluation Level 4: Participant Use of New Knowledge and Skills

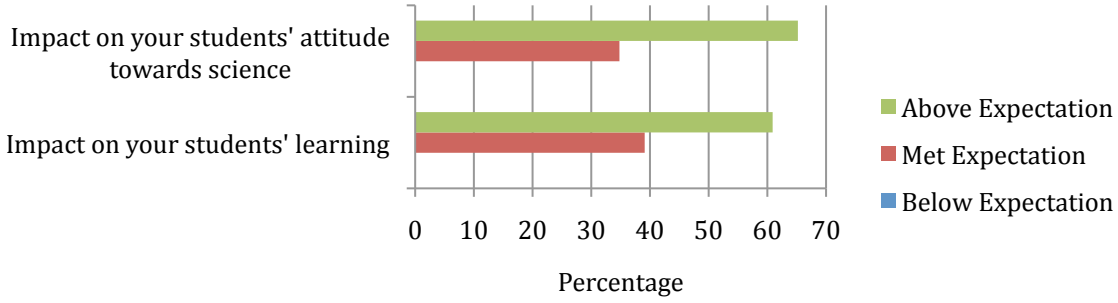


In a separate survey question, 21 out of 25 teachers saw the GK-12 program as an "opportunity to deepen my science content knowledge." This agrees with the results of a national survey in which experienced teachers expressed the need for PD that focuses on new topics (Chval et al., 2008). As seen above, teachers perceived that this goal was achieved. A correlated question showed that 79.2% of teachers reported that the GK-12 program increased their knowledge of the science content that they teach, and 83.3% reported an increase in science content knowledge more advanced than they teach. Teachers attributed this mostly to their involvement with their fellow through frequent, ongoing discussions.

Teachers also perceived changes in their teaching practices as a result of their involvement with GK-12. In a correlated survey question, twenty-one teachers reported that they teach science content in more depth. Twenty were more likely to have students work on science investigations where they do not know the outcome in advance, include current science research in their lessons, and engage students in dialogue. Eighteen were more likely to use hands-on, laboratory activities and less direct instruction. These teaching practices complement the national science standards and also reflect a challenge

to the traditional method of teaching (Gess-Newsome, 2003). These types of teaching strategies require strong pedagogical and content knowledge.

Evaluation Level 5: Student Learning Outcomes



In a separate survey question, 22 out of 25 teachers saw the GK-12 program as a way to "help my own K-12 students." This agrees with the results of a national survey in which experienced teachers expressed the need for PD that focuses on student learning (Chval et al., 2008). In a correlated question, teachers rated the impact of the GK-12 program on their students as being positive in all areas: student knowledge, science skills, and attitudes towards science. Teachers attributed this to having a "scientist-in-the-classroom" who provided real-life applications and a view into the work of a scientist:

> *The GK-12 program…enabled me to have honest discussions with students about the nature of science and the work of scientists.*
>
> *Watching my students get excited about a scientist coming to school and how female students responded to a female scientist was an eye-opener – it was obvious that some female students had never considered becoming a scientist.*

The teachers also remarked how the scientist also brought new and innovative lab experiences for the students:

> *[I was] willing to try new/different experiments and demos without reservation.*
>
> *[The greatest impact was]designing and implementing new labs that incorporated current research.*

In summary, the results of the survey showed that the participating teachers did find the GK-12 program to provide effective professional development as measured using Guskey's five levels of evaluation: 1) participant reaction, 2) participant learning, 3) organizational support and change, 4) participant use of new knowledge and skills, and 5) student learning outcomes. However, we need to understand why the teachers found it effective if we are to create a model for the use of reciprocal coaching as a differentiated professional development strategy.

Can the GK-12 program be used as a model for reciprocal coaching as a differentiated professional development strategy?

To answer this second research question, eight teachers were interviewed. Interview analysis revealed four themes to consider for reciprocal coaching to serve as a model of professional development for experienced teachers: 1) reciprocal coaching as professional development 2) perceived benefits of participation, 3) the reciprocal nature of the teacher-scientist team, and 4) sustainability.

Theme 1: Reciprocal Coaching as Professional Development

The first theme to emerge from the interview data was the teachers' viewpoint about the GK-12 program as professional development. The teachers interviewed all described extensive professional development experience through their district and regional centers; on the whole, these were teachers who are continuing to improve their craft even after years of teaching. The teachers remarked that they were always searching for professional development opportunities. When asked what they considered to be 'good' professional development, common themes arose – the need for the information to be new to them, to be subject (in this case, science) specific, to be hands-on or interactive, and to have direct application to the classroom. When asked about what aspect of the GK-12 program was the most beneficial professional development activity, the teachers often referred to the weekend workshops and evening lectures – the more traditional forms of PD. However, about half of the teachers did not equate the in-classroom interactions with their fellow as professional development. Only when prompted by the researcher did the teachers consider this concept. Here is one teacher's response to the question "So, this in-classroom interaction that you're talking about and then the planning that goes around it, would you consider that professional development?":

> *I think in a way. I don't know that it is as much. I mean, and I should go back…She did find some great labs that I had never done. I would consider that professional development. I think having conversations with anybody about a topic you're going to present, I would consider that professional development. So that interaction, you know, setting aside the difficulty of really, you know, taking stock of what's expected of me, setting that aside, the interaction and focus, just*

how to structure things differently, "And oh what about if we do this?" And from her doing the lab instead of me, I kind of — you know, how you can stand back and watch how somebody does something and you come up with ideas?

Um…I guess so. I mean, like I said, I learned a lot from [my fellow],because of her background being so different from mine. I guess if you consider -- I mean, yeah, I would say so. Oftentimes, we think of professional development as how to work a classroom, you know, classroom management, different activities, that kind of stuff. So, I'm not really sure.

It is evident that these two teachers are grappling with their concept of professional development and their definition of it. On the other hand, half of the teachers interviewed unproblematically considered the in-class time as being professional development, claiming that the interaction with the fellow in preparing the lessons, teaching the lessons, and de-briefing the lessons was the most beneficial for them. This is due to the overall amount of time devoted to these activities as well as its highly contextual nature as it occurs in the teacher's own classroom, as one teacher explained:

For me, by far, this is the best professional development that I've been involved in. Just because it was really holistic. You know, there were several different aspects of it where we had field experiences or field trips that we did as fellows and teachers together, which would be a little bit more like what a good professional development that a teacher might typically go to would be. But I think some of the less tangible professional development things that have happened are just when you have someone else in the room, to kind of being aware of different ways that you're communicating something: how a question came across, who understood something that someone else didn't.

The idea of the professional development being 'holistic' and connected resounded with another teacher as well. Below, the teacher describes how the workshops and her interactions with the fellow complemented each other, increasing her ability to use the workshop content in her classroom with her students.

I did feel that the interaction with [my fellow] brought everything that we learned more into perspective and kept it from fading away. For one, you know, sometimes you go to a workshop, it's really good and everything, but if you don't use it, you sometimes forget it or forget the end. And so it was like, okay, because he did so many other things with the kids that were similar to things that I did, you know, I was able to connect that experience, relay it the kids. You know, "This is what we did. You're going to really love this." And then, two, some of the things that he would talk about, I knew what he was talking about because of going to the classrooms or hands-on out at [the workshop location]. So, I'd have to say it meshed. You know, it made the connection, so that everything was smooth.

In conclusion, out of the 8 teachers interview, half found that the classroom-embedded aspect of their work with the fellow did not align with their view of professional development. Their image of professional development was more in line with the traditional structures such as workshops. This may be a very important consideration if classroom-embedded professional development is to be implemented as a part of educational reform – this could prove to be quite a roadblock if teachers or policy makers do not view this as professional development. However, in discussion of the next theme, the teachers describe their learning within the classroom, which would strengthen the case for use of this type of strategy.

Theme 2: Perceived Benefits of Participation

Teachers reported that they benefitted from the program in numerous ways. While all of the teachers shared an overall enjoyment of participating in the program, teachers also described increases in their knowledge. Many of the reported benefits align with other recent research by Rodriguez and Gess-Newsome (in review) describing the

benefits to student teacher mentors using Shulman's Knowledge Base for Teaching (Shulman, 1987) as an organizational and theoretical framework to describe teacher learning. Teachers in this study reported similar gains in increased content knowledge, pedagogical content knowledge, curriculum knowledge, knowledge of learners and their characteristics, and knowledge of educational contexts and ends as a result of their participation in the GK-12 program.

Content knowledge is the knowledge of science content specific to the course as well as additional background knowledge of the teacher. Content knowledge has been positively correlated with student achievement (Hill, Rowan & Ball, 2005). All teachers reported an increase in content knowledge, often claiming gains beyond what was needed to teach their course. An exemplar statement of a teacher expressing the benefit of personal content knowledge at a level higher than which they teach:

> *We're getting just now into our discussion about cells and cell theory and so on. But just to have that background knowledge has helped me to understand more about classification and about how we order and organize the world, which has made it easier for me to relate to the subject matter with that.*

Pedagogical content knowledge (PCK), unique to teachers, is the combination of content and pedagogy. Aspects of PCK include common student misconceptions and techniques for learning specific to the subject, in this case, science (Shulman, 1987). Teachers with strong PCK would seek relevance in their choice of student activities; all interviewed teachers found value in presenting current, lab-based lessons with their fellow. In answer to why they found this program so rewarding, one teacher said:

> *Because it's current science and it's lab-based. And it's not looking back over something that was done 10 years ago, not repeating everything under the sun. It's what is going on now and how can we take that and incorporate that into a lab-based lesson that will address what [the standards] wants you to address.*

Curriculum knowledge serves as guidance and resources in finding or creating lessons for students (Shulman, 1987). All teachers in this program came from schools that had clear content standards set at the state level, but allowed flexibility in how the content standards were to be taught. The majority of the teachers referred to their curriculum or standards when talking about lesson planning with their fellow. An exemplar voice:

> *[She] was the first fellow that I worked with. And when she came in, we sat down and looked at the curriculum and looked at where there were holes in the curriculum, where the curriculum really needed help. As far as new labs that were coming up, what was going on now in science. That's when we hit on looking at GIS…And so, she was talking about it and showing what she had done for her graduate work…And, then it was kinda like…couldn't we teach these students how to do this. And, it was like why not? If we break it down in steps, why can't these 6th graders use GIS?...And it was the most successful thing I have ever done.*

Knowledge of learners and their characteristics includes being able to monitor student progress, misconceptions, and interactions at an individual level (Shulman, 1987). The majority of the teachers reported gains in knowledge of learners. The following quote exemplifies how the teachers found the ability to do this increase when they were able to be reflective and view their classrooms through the eyes of their fellow. This vicarious experience was eye-opening for many of the teachers.

> *[My fellow] isn't here as often as I am, so it's interesting, because she'll pick up things about the girls that maybe I don't, because I see them every day. So, not that I'm tuned out to it, but we just go, go, go, go. And she'll remember little specific things about what one girl said or what one girl's response was to something. And I think that it's always really important to be reminded of just those pieces as a teacher. So, I just found it really beneficial, because there were things that I could reflect on, on a lesson-by-lesson basis when it came just to student interaction, questioning, [and] communication.*

Knowledge of educational contexts and ends allows teachers to place their experience and classroom within the larger educational context at the district or community level as well as within the philosophical frameworks for education (Shulman, 1987). One teacher in particular, who had an overall good experience with her fellow, showed a strong change of perspective about her work because of changes to her curriculum at the district level. She was asked to use 20% of her instructional time during the first six-weeks grading period to teach a unit on drug use prevention. The following excerpt indicates how having a fellow gave her a different perception of her work.

> *I had a really tough first six weeks. Well, first [six weeks] and having that yanked out from under your feet—that 20% of your teaching time, more so. So, I really, I did not know I had become so…. It's almost like having a thorn in your shoe and getting used to it. I did not realize how difficult my job was. I mean, I knew it was tough… but I just…. It was just a shock to have to turn…. But to have to put out there all the stuff that we trudge through, just put out there so much, you know, just rubbed it in my face pretty much how ungrateful and unrealistic the rest of the world is about what we do. So it was tough!*

In conclusion, teachers reported knowledge gains as a result of their participation in the program. The types of knowledge specific to teachers, as categorized by Shulman,

included content knowledge, pedagogical content knowledge, curriculum knowledge, knowledge of learners and their characteristics, and knowledge of educational contexts and ends. So, although some teachers may have had difficulty in classifying their in-class time as professional development, as seen in the first theme, they all reported learning through that very same experience within the classroom. Next, we will examine why the teachers thought this program was successful.

Theme 3: Reciprocal Nature of the Teacher-Scientist Team

All of the teachers remarked on the collaborative nature of their successful relationship with the fellow, but what characteristics made it such? Teachers remarked about their teaching experience level and the fellow's scientific background as being markers of success. All teachers discussed the value of collaborating with their fellow through planning lessons together, co-teaching the lessons, and debriefing afterwards. They felt their work was successful because what the teacher had to offer and what the fellow had to offer was complementary as exemplified in the following quotes:

> *I feel like because [the fellow] and I had different backgrounds, we had a lot to — like, we could come together and when the kids asked questions, we both had something to pull from that gave [the students] a much broader sense of what they wanted to know.*
>
> *[My fellow] and I really played well off of each other. I would come in and introduce the class, kind of go over what we were going to do, what our goals were, any safety things, kind of get them situated and ready, and then [my fellow] would take over, introduce the lesson itself, like what she needed, background information, anything she needed them to know, directions, and then we would work the lab together. And then as we had questions, we would just kind of take*

turns. I mean, it was -- after a couple of times, it was just almost seamless, like we just went at it and it was natural.

Five teachers cited their own experience level as a reason for why their work with their fellow was successful. They felt that by having more experience, they had more to offer the fellow and thereby enhancing the reciprocal nature of their work. The teachers often conveyed this by contrasting what a new teacher would have to offer.

I feel like if [my fellow] gained anything in terms of communication or questioning or any of that from me, that I had a lot more of that to offer now compared to if I were a second year or third year teacher.

I would say an experienced teacher is what the fellow needs to be in with. Because they know the angles and different things and to help them out. Also, for the...I think a seasoned teacher would also get the most benefit out of that because we get to a point where we're gleaning ideas wherever we can. We're the scavengers who get supplies here and there. So I just think that we are more attuned to if something new comes in, we're going to pick their brain and try to get what we can to make our classrooms more successful. I think that's what a seasoned teacher would do.

While the other three teachers referred to their ability to maintain discipline in the classroom or their flexibility and comfort within their curriculum as the main determinants of their success, which one could arguably say would be skills and attitudes that an experienced teacher would have better established than a new teacher.

Yeah. I think it did, because I was able to…. Because my classroom management technique is there, I was able to handle all of that, so [my fellow] could concentrate on, you know,"This is what we're learning. You have questions. Here's the answer in my experience."

I know it's a pretty common teacher thing to have trouble letting go of your room. And I'm just a little more of a beta personality. Not always, but when it comes to some things like that. I know people that just cannot let it go. And it might be a little bit of a function that my curriculum was changing this year, so I felt a little

bit more freedom to be like, well, let's just see, and, you know, I can always tweak it and we won't do that — I won't do that next year, or, you know, we'll have to…. A couple of times, I know I was like, "Okay, I really need to get to this piece of the curriculum now."

The majority of teachers also made a clear distinction – the fellow was a scientist, not a teacher. The benefit of having a fellow in the classroom lay within their content knowledge and their 'scientist' status. Although many of the teachers have degrees in science, the teachers commented that the fellow's content knowledge was both more current as well as more in-depth.

But being able to have his science background…. And I'll say I'm a scientist, but I've never been in a lab. I've certainly never conducted rigorous experiments. We've done our own investigations and things, and I know the scientific method, but to actually have stuff mess up that you don't really know why it's messing up other than, you know, here's this sort of cookie-cutter activity and that didn't work. What was it? Oh, well, look at all the leftovers in the glass. We didn't clean this well enough. Fine. But to truly do that, and he's been doing that, and having that as an adjunct to what we're doing in class. So, I think his whole sort of approach to getting the students…getting them to investigate, what are the origins of this rock? It came from a standpoint of, you know, what are the markers that we use to define rock? And certainly I don't understand the rock's alkalinity, but the movement of the particles and all of these things. And that was information I wasn't aware of and didn't have. And so, it expanded a whole section of science for me.

I really think if I did it again, as a teacher, I can think of a hundred ways that maybe just each time I could bring in the fellow's research in some way, shape, or form, or just the scientist part.

The teachers knew that the fellows were there to gain classroom teaching experience, however many differentiated between the fellow and a student teacher because of the focus on science versus pedagogy.

I think with a student teacher there's going to be more focusing on how to teach versus on what we're teaching. Like…with the fellow, we were able to focus on what we were teaching…we talked about the science behind it.

I was...when you are mentoring a student teacher, you are trying to help them learn how to do classroom management, learn how to teach, learn how to do the ins and outs of the paperwork, the technicalities, looking at classroom management, timing, thing of that sort. I wasn't necessarily…I wasn't trying to teach the graduate fellows how to teach. I was more interested in what new science can [the fellow] bring into my classroom.

In conclusion, teachers identified that their participation in the GK-12 program was successful due to the reciprocal nature of their working relationship with the fellow. The teacher and the fellow did not have overlapping skill sets and therefore were complementary to each other's learning. Teachers thought they offered skills and knowledge based upon their level of experience as a teacher, while the fellow offered skills and knowledge based upon their level of experience as a scientist. The reciprocal and complementary knowledge and skills contributed to the success of the coaching relationship. This is in contrast to the typical reciprocal coaching dyad of two teachers who would likely have much more overlap in skills and knowledge. It is this particularly unique aspect of the GK-12 program – pairing a teacher with a scientist rather than another teacher – to which the teachers attributed their learning. One important measure of the effectiveness of professional development is the sustainability of the teacher's learning (Guskey, 2000); the next theme will examine this metric.

Theme 4: Sustainability

Although most of the teachers indicated that they could continue some aspects of the GK-12 program through their closer association with the university or individual fellows, by and large the types of activities they mentioned – such as visiting scientists, guest speakers or science clubs – would be less frequent. Because of the lack of prolonged engagement with the scientist, the teachers felt that neither they nor their students would benefit as greatly. One teacher discussed this within her teaching context with students with a high degree of poverty:

> *Well, I think an ongoing relationship with anyone that's a productive, constructive member, when you're in 75-80% population of poverty, to have a long-term relationship where no one abandons you and they have no visible payoff for it, that's amazing. You can't replace that. Somebody that says, "Here, I did this with my researcher. I did that." Or, they see that evolve and they see her excitement about what she's doing, and it's long-term, versus, "Hi. I popped in to see you." You can't replace that.*

Another teacher also indicated the importance of the long-term sustained relationship but added how difficult he thought it would be to replicate on his own.

> *And so, that would still get the interaction of a scientist with the students, but it wouldn't be building the relationships. It would just be, you know, "Here's a scientist. They don't look like Einstein. And here's what we're doing. Come on, guys." So, I think that, for me, I could certainly…. I mean, if it was a question of being able to get somebody to come to the classroom that would do it. And that's about, you know, being able to have somebody that can find the time to do that sort of thing, and so it's somewhat prohibitive. It's hard to reproduce. It's hard to replicate.*

And when speaking of continuation of the project, one teacher emphasized the lasting effects on her own knowledge and was confident of her growth, but was saddened that the students would be the ones who would be missing such an enriching experience.

> *But it will be a totally different experience, you know, actually having a scientist in the room and someone that the girls know is coming. I mean, you know, they won't even know that that's an option, so in my mind, it'll be like, "Oh, this lesson is much better than the activity I did three years ago for this," but they won't know. And so it'll be a very different experience. I still think it'll be, you know, as a teacher, that growth will have happened because of the program, and that'll affect my classroom next year, but it's too bad, you know, that the students won't be able to have the same experience.*

The teacher above indicates that she will be continuing to use the lessons she and her fellow developed and teachers who have been in the program for several years remarked they still do the labs and lessons created with their fellow, however they have had to scale them back. The difficulty in enacting the same lesson was due to high complexity, lack of having the extra person to help, or lack of resources or specialized materials. When asked whether she would be able to do the labs co-created with her fellow, one teacher remarked, *"I would say about 90% of them. Some of the stuff that [my fellow] brought in, I don't know if I'll be able to obtain on my own."* Another teacher offered another set of difficulties related to materials and space:

> *Oh, yes. Oh, definitely, beyond a shadow of a doubt. I might have to scale them different. Bless her heart, she decided, and my teaching partner, they both decided that every child should build their own biosphere, which if you have ever done that, we have 134 students!*

In conclusion, the majority of teachers felt that they might be able to use their connection with the university to bring in guest scientists, however the lack of sustained contact would decrease the impact of learning for both themselves as well as their students. Likewise, most teachers acknowledged they would be able to teach with the co-created lessons and labs but would most likely have to scale them back due to lack of resources.

In summary, the results of the interview show that even though the teachers reported increases in the different types of knowledge for teaching, half of the teachers did not consider the in-classroom time to be professional development. And, when pushed, continued to struggle with the notion of this non-traditional format as being PD. Additionally, the teachers attribute a reciprocal relationship with the scientist as being the main reason for their success, however, the teachers did not feel that they would be able to individually initiate a sustained reciprocal coaching relationship with another scientist.

Chapter 5: Conclusion

Discussion

I was motivated to conduct this study because as a teacher of 12 years, I noticed a lack of good professional development for experienced teachers. I was a participating teacher in the GK-12 program in 2004-5, and then more recently acted as the program coordinator. I found the GK-12 program to be effective, and I wondered if my experience was common. From a research standpoint, I wondered what larger lessons about classroom-embedded professional development could be learned. This study attempted to examine whether the program was effective and then, if so, to what we could attribute this effectiveness.

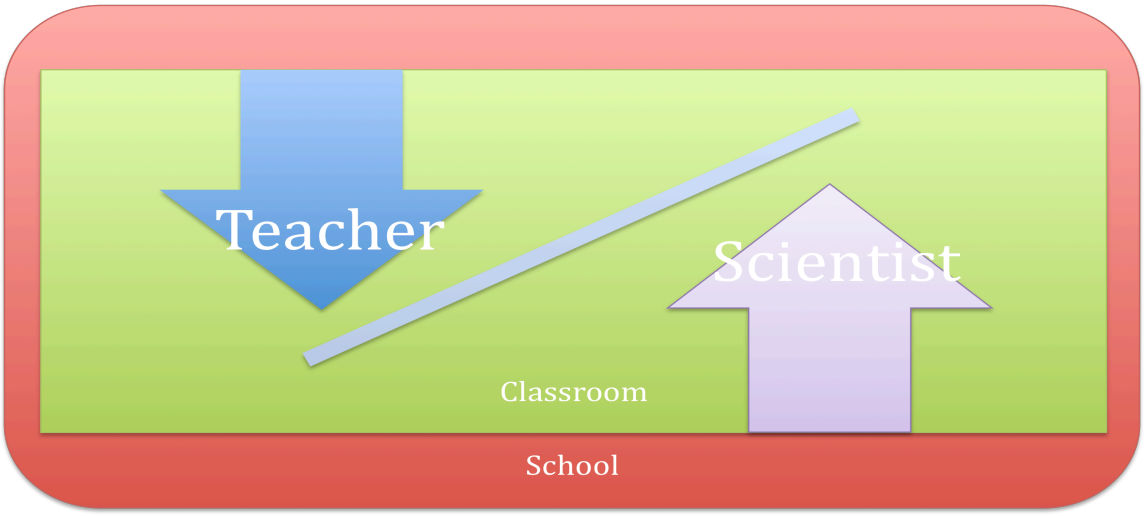
First, did the teachers view the GK-12 program as providing effective professional development? These site-specific results compare favorably with the national study conducted by Abt Associates for NSF in 2010 with a larger sample size of roughly 740 teachers. The goals for participation stated by the teachers in that study were identical to those in this smaller study: to help their K-12 students and to deepen their personal content knowledge. The results of this study seem to indicate that the participating teachers perceived this professional development as effective in meeting their stated goals. Likewise, the national study found that the teachers perceived that these goals were successfully attained. While teachers reported high levels of enjoyment, quality and motivation, they also expressed concern about the amount of time that the

program required, the organization provided through the university, and the application to their classroom. The last concern was perhaps the most surprising as the PD takes place in the teachers' classrooms, one would assume that it would be applicable. And, in fact, this assumption is the basis for the U.S. Department of Education's reasoning for including it in recent policies concerning educational reform (Croft et al., 2010). Overall, the results of the study showed that this group of experienced teachers did consider the professional development to be effective; therefore, we need to understand how and why this strategy was effective to use it as a model for differentiated professional development.

Second, can the GK-12 program be used as a model for reciprocal coaching as a differentiated professional development strategy? This study supports the conclusion that these mid-career, accomplished teachers found reciprocal coaching to meet their individual needs as experienced teachers. Thus, reciprocal coaching may provide the opportunity to individualize and differentiate professional development. While the teachers reported knowledge gains through their collaborative, reciprocal relationship with their fellow, some teachers struggled with the idea that the classroom time counted as professional development. This is precisely the type of professional development that is called for in our quest for educational reform – to place teachers in the role of both learner and teacher through new professional development strategies such as coaching and placing novices next to experts (Darling-Hammond & McLaughlin, 1995). Furthermore, classroom-embedded professional development is considered an evidence-based "best practice" (Garet et al., 2001). This research implies then, that there may be

barriers to using this type of professional development, namely the viewpoint of whether it 'counts' as professional development.

Figure 5. Reciprocal coaching model with teacher-scientist dyad



The teachers attributed their success to the complementary, non-overlapping skills between themselves and the scientist with which they worked. This presents an interesting alternative model (see Figure 5) to the traditional reciprocal coaching model between two teachers. It is my hope that other programs will find value in placing a scientist in the classroom and utilize this model for future professional development programs.

Implications

Limitations in drawing conclusions from the data can be attributed to the nature of self-report, the small number of participants, the highly contextual nature of the qualitative methods used, and perhaps my connection to the program. First, self-report

surveys can only record the perceived impact on the classroom; to validate the teacher's responses, student interviews and classroom observations would have to be conducted. However, the results of the survey and responses in the interview did triangulate. Second, while this study had a smallish sample size, the results compare favorably with a much larger national sample, reducing concern about it validity. Third, the results of the interview are highly contextualized within the teachers' experiences therefore caution should be taken to not over-generalize the results. Lastly, I was a teacher in this GK-12 program during the 2004-5 school year and then later in 2010-11, I was the program coordinator. Although I had my own positive personal experience with the program, I wished to see how other teachers perceived their experience. I do not believe that my involvement, however, influenced the participants as most did not know me.

Future research is needed to create effective professional development opportunities that meet the needs of experienced teachers. Reciprocal coaching is one of those strategies that can be used to individualize professional development and not only connect it to classroom practice but embed it within the classroom. In the absence of structured programs, such as GK-12, how can these opportunities be offered and supported? What conditions are needed to ensure that reciprocal coaching is effective in meeting teacher needs? How can these types of opportunities be offered to larger groups of teachers? Future research must tackle these and other important questions to continue to support efforts for science education reform.

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